“This is an Accepted Manuscript of an article published by Taylor & Francis in Studies on Neotropical Fauna and Environment on 14 Oct 2019, available at http://wwww.tandfonline.com Article DOI: 10.1080/01650521.2019.1676620”

Comparative composition of the snake assemblage from Sierras de Ventania mountain range, east-central Argentina

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ABSTRACT

The composition of a snake assemblage from an orographic island in east-central Argentina, the Sierras de Ventania mountain chain, was analysed. The aim was to determine the biogeographic resemblance to other snake assemblages from neighboring regions. Species composition of each region was obtained from an exhaustive review of the literature, and both fieldwork and museum records. The higher biogeographic resemblance of the Sierras de Ventania occurred with the Sierras de Tandilia and the Coastal Dunes. These regions formed a well-defined group according to their snake assemblages. On the other hand, the Sierras de Lihué Calel linked to the Sierras de Ventania, and also to the rest of the compared regions, at very low values of biogeographic resemblance. The results obtained in this study contrasted with the classic zoogeographic scheme. Snake assemblages allowed recognising a more significant division between Central and Pampean domains. In this scheme, the limit between these two regions moved to the southwest of the classical scheme; therefore the Sierras de Ventania was part of the Pampean domain. Also, the recognition of the Subtropical domain was evident, as well as its faunistic link with the Pampean domain.

KEYWORDS

Biogeography; Pampásico; snake communities; South America

Introduction

Comparison between snake assemblages can be complex when different environments and areas are related, and when there are differences in the sampling methods, added to the difficulty of finding snakes during fieldwork (Martins & Oliveira 1998; Bernarde & Abe 2006; Sawaya et al. 2008). Additionally, some variables such as altitude, latitude, temperature, precipitation, and vegetation also influence the species richness in the snake assemblages (McCain 2010; Nogueira et al. 2019). Besides to these variables, historical factors are also responsible for the composition of snakes in any given region, as shown by the increase of Xenodontinae with the increase in the southern latitude, together with the morpho-physiological constraints that allow the species survive in a particular habitat (Cadle & Greene 1993).

Zoogeographic studies regarding Argentine snakes are mainly approached on the phytogeographic divisions (e.g. Cabrera 2001; Giraudo 2001). According to Ringuelet (1961), the adjustment between the zoo and phytogeographic units is expected and even desirable. In their zoogeographic schemes, Ringuelet (1955, 1961) and Ringuelet and Arámburu (1957) considered that, in Buenos Aires province, the area from the Colorado River to the Sierras de Ventania presents a faunistic link with the Monte ecoregion and therefore is part of the Central domain (Figure 1). However, from the phytogeographic point of view, the Sierras de Ventania is included in the Pampean ecoregion (Cabrera 1976).

The Sierras de Ventania is an isolated orographic system located in the southwest of Buenos Aires province, Argentina (Sellés Martínez 2001). The four main mountain chains are Sierra de Cura Malal, Sierra de la Ventana, Sierra de las Tunas and Sierra de Pillahuincó, with altitudes of 1015, 1243, 650 and 550 masl, respectively. The area is biologically rich and home to several endemic species, the reason for which it has been defined as an orographic island (Cranwell 1942; Crisci et al. 2001). From the first herpetological list (Koslowsky 1895) to subsequent records (Couturier & Grisolia 1989; Viñas et al. 1989; Di Pietro et al. 2018) a total of 15 snake species have been reported in this region. One of them is microendemic: *Lygophis elegantissimus* (Koslowsky).

The present contribution analyses the composition of the snake assemblage from Sierras de Ventania, an orographic island in east-central Argentina. The aim is to determine the biogeographic resemblance of this snake assemblage with other snake assemblages from neighboring regions. The hypothesis to be tested is that the Sierras de Ventania snake assemblage presents similarity with snake assemblages of the Pampean ecoregion, or alternatively, with snake assemblages of the Monte ecoregion.

Materials and methods

The biogeographic resemblance of the Sierras de Ventania snake assemblage was assessed comparing to other regions. Species composition of each region was obtained from an exhaustive review of the literature, which also included our previous fieldwork and museum records (see below). Snakes from Sierras de Ventania were hand-captured using transect and road-riding surveys (Foster 2012) during 15-week-long study periods between February 2010 and March 2014. The snake assemblages used to compare were constructed on the basis of museum specimens housed at the Museo Argentino de Ciencias Naturales “Bernardino Rivadavia” (MACN, Buenos Aires), Museo de La Plata (MLP, Buenos Aires) and

Fundación Miguel Lillo (FML, Tucumán). Only lists of confirmed presence snakes (with voucher specimens or precise locality information) were considered, and then posterior species records with identical locality were added, as appropriate. The abiotic data (mean temperature, precipitation, and altitude) in each region was obtained from the Servicio Meteorológico Nacional (https://www.smn.gob.ar).

Regions and departments compared in the present study, and the source of information, are as follows (see Figure 1). Buenos Aires province: (1) Northeast (NE), including the departments of Baradero, Berazategui, Berisso, Cañuelas, Exaltación de la Cruz, Florencio Varela, La Plata, Lincoln, San Fernando and San Miguel (Gallardo 1980; Di Pietro & Nenda 2007; Di Pietro et al. 2010); (2) Parque Rafael de Aguiar (PRA), San Nicolás (Voglino et al. 2001); (3) Reserva Natural Otamendi (RNO), Campana (Pereira & Haene 2003); (4) Reserva Natural Punta Lara (RNPL), Ensenada (Saibene et al. 2012); (5) Parque Costero del Sur (PCS), Magdalena and Punta Indio (Gallardo 1987; Nenda & Di Pietro 2009; Williams & Kacoliris 2009); (6) Salado River Basin (SRB), Ayacucho, Azul, Castelli, Chascomús, Dolores, General Alvear, General Belgrano, General Guido, General Lavalle, General Madariaga, General Paz, Las Flores, Maipú, Monte, Pila, Rauch, Roque Pérez, Saladillo, Tapalqué and Tordillo (Gallardo 1976; Nenda & Di Pietro 2009); (7) Sierras Bayas (SB), Olavarría (Nágera 1915; Barrio 1961); (8) Sierras de Balcarce and Mar del Plata (SBM), Balcarce and General Pueyrredón (Vega & Bellagamba 1990); (9) Coastal Dunes (CD), Coronel Dorrego, Coronel Rosales, General Alvarado, La Costa, Mar Chiquita, Necochea and Villa Gesell (Kacoliris et al. 2006; Celsi et al. 2008); (10) Sierras de Ventania (SV), Coronel Pringles, Coronel Suárez, Puan, Saavedra and Tornquist (Koslowsky 1895; Couturier & Grisolia 1989; Viñas et al. 1989; Di Pietro et al. 2018). La Pampa province: (11) Sierras de Lihué Calel (SLC), Lihuel Calel (Tiranti & Avila 1997; Di Pietro et al. 2013).

The coefficient of biogeographic resemblance (CBR) was calculated as follows: CBR = 2 C / (Na + Nb); where C is the number of common taxa to both *a*, *b* compared regions, Na is the total number of species and subspecies for the first region, and Nb is the total of species and subspecies for the second region of the pair (Duellman 1979). The CBR is an index of resemblance based on binary data (presence/absence) and was adopted here because it is a robust coefficient used in previous works about Neotropical herpetofauna (e.g. Duellman 1990; Cabrera 2001). Based on the CBR values, a dendrogram of compared regions was obtained through the UPGMA algorithm and Bray-Curtis similarity index, using PAST software (version 3.04, Hammer et al. 2001).

Results

The species richness of the Sierras de Ventania was similar to the rest of the compared regions (Table 1). The Northeast area presented the highest number of species and subspecies of snakes (n = 17), followed by Sierras de Ventania, Parque Costero del Sur, and Sierras de Lihué Calel (all regions with 15 species). In the rest of the compared regions, the species richness decreased slightly (Table 1). There were no snake species distributed in all the regions compared to in the present study. However, *Bothrops alternatus*, *Erythrolamprus poecilogyrus sublineatus*, *Lygophis anomalus* and *Paraphimophis rusticus* were found in almost all the regions, while other species presented a restricted distribution to a particular sector, such as *Psomophis obtusus* in the Northeast, *Lygophis elegantissimus* in the Sierras de Ventania, and several snake species in the Sierras de Lihué Calel (Table 1).

The CBR revealed the highest biogeographic similarities (i.e. values of CBR ≥ 0.75) between the Sierras de Ventania and the Coastal Dunes, the Sierras de Balcarce and Mar del Plata, and the Sierras Bayas, respectively (Table 2). All species found in these regions (except *Thamnodynastes hypoconia* recorded in the Coastal Dunes) were represented in the snake assemblage of the Sierras de Ventania. The Northeast presented high values of biogeographic resemblance with the Reserva Natural Punta Lara and with the Parque Costero del Sur. The species recorded in these regions (except *Taeniophallus poecilopogon* cited for the Parque Costero del Sur) were also represented in the Northeast (Table 1, 2). On the other hand, the Sierras de Lihué Calel showed very low values of biogeographic resemblance. The highest biogeographic similarity of this region was with the Sierras de Ventania (CBR = 0.40, Table 2).

The dendrogram obtained through the UPGMA algorithm for the CBR values showed the Sierras de Lihué Calel separated from the regions of Buenos Aires province at very low levels of resemblance (Figure 2). The remaining regions formed two well-defined groups, one composed of regions linked to the Atlantic coast and Mountain range systems (Sierras de Ventania, Coastal Dunes, Sierras de Balcarce and Mar del Plata, and Sierras Bayas) and other composed of regions linked to the Río de La Plata coast and Salado River Basin (Northeast, Reserva Natural Punta Lara, Parque Costero del Sur, Parque Rafael de Aguiar, Reserva Natural Otamendi and Salado River Basin, Figure 2). The correlation coefficient obtained (r = 0.97) suggested a good representation of the relationships established between the snake assemblages.

Discussion

As stated above, making comparisons between species composition in different snake assemblages is difficult due to several factors, such as differences in the size of study areas, sampling efforts, and methods used (Martins & Oliveira 1998; Bernarde & Abe 2006; Sawaya et al. 2008). Also, variables such as latitude and altitude, temperature, precipitation, as well as the vegetation influence the species richness in snake assemblages (McCain 2010; Nogueira et al. 2019). Species richness of the Sierras de Ventania was similar to the observed values in the other regions compared. Decreasing of species richness with the increase of latitude and decrease of temperature was evident when comparing the Northeast with southern regions. However, two localities at the north of Buenos Aires province, the Parque Rafael de Aguiar and the Reserva Natural Otamendi (Voglino et al. 2001; Pereira & Haene 2003, respectively) presented low species richness compared to the Northeast (data from Gallardo 1980). In these regions, other factors must be influencing the low number of snakes, such as the differences in the size of the study areas (see Figure 1). As mentioned by Gallardo (1977), in Buenos Aires province the two zones with the highest snake richness (and reptiles in general) correspond to the Northeast and the Sierras de Ventania. Similarly, in this last region other factors must be influencing the high species richness in relation to the latitude, such as the higher altitude.

In addition to these variables, historical factors are also responsible for the composition of the snakes in a given region, as shown by the decrease of Colubridae and Dipsadinae and the increase of Xenodontinae with the increment of latitude (Cadle & Greene 1993). This tendency was more evident when comparing with distant regions. For example, in the Manaus region, Brazil, Masseli et al. (2019) recorded 29 snake species

(23.8% Colubridae, 19.1% Dipsadinae and 57.1% Xenodontinae, within Colubroidea *sensu* Zaher et al. 2009) in the Experimental Farm of the Federal University of Amazonas. Scrocchi and Giraudo (2005) recorded 33 snake species (10.7% Colubridae, 10.7% Dipsadinae and 78.5% Xenodontinae) in El Bagual Reserve, north Argentina. Finally, in the regions compared here, the richness did not exceed 17 species, Colubridae and Dipsadinae were absent, and Colubroidea was exclusively represented by Xenodontinae.

Most of the zoogeographic schemes regarding Argentine snakes have been ruled by the phytogeographic divisions (see Cabrera 2001). The regions compared in the present study coincide geographically with three zoogeographic domains: Subtropical (with arboreal vegetation and high mean rainfall), Pampean (corresponding to the grassland steppe) and Central (with Monte vegetation, currently almost disappeared in Buenos Aires province; Ringuelet 1955, 1961; Ringuelet & Arámburu 1957, see Figure 1). These units reproduce approximately the phytogeographic scheme (Cabrera 1976): Pampean province (Subtropical and Pampean domains), Espinal and Monte provinces (Central domain). Interestingly, within the Neotropical region, Subtropical and Pampean domains belong to the Guayano-Brasileña sub-region, whereas the Central domain belongs to the Andino-Patagónica (Ringuelet 1961).

The higher biogeographic resemblance of the Sierras de Ventania occurred with the Coastal Dunes and the Sierras de Tandilia (represented by Sierras de Balcarce and Mar del Plata, and Sierras Bayas). These regions formed a well-defined group according to their snake assemblages. Ringuelet (1955, 1961) and Ringuelet and Arámburu (1957) did not consider the Sierras de Ventania part of the Pampean domain. According to these authors, in Buenos Aires province, the zone from the Colorado River to the Sierras de Ventania represents a faunistic link with the Monte ecoregion and, therefore, is part of the Central domain. In contrast, the results obtained in this study, linked the Sierras de Ventania with the Pampean domain, more precisely with the Tandílico and Costero sectors (*sensu* Ringuelet 1961). Also, the individuality of the Sierras de Ventania was not entirely clear. Although it presented an exclusive snake (*Lygophis elegantissimus*), other characteristic elements of the Central domain were absent (e.g. *Philodryas p. psammophidea* and *Erythrolamprus s. sagittifer*). This snake assemblage could be defined as Pampean with some species of more xeric habitats (e.g. *Epictia australis* and *Bothrops ammodytoides*). Supporting these results, the Sierras de Lihué Calel, which is included in the Central domain and the Monte province (Ringuelet 1961; Cabrera 1976), separated from the Sierras de Ventania, and also from the rest of the compared regions, at low values of biogeographic resemblance. Similar results are indicated for micromammal assemblages (see Pardiñas et al. 2004). Interestingly, the finding of some snake species typical of the Monte ecoregion at southwest of the Sierras de Ventania (e.g. *Pseudotomodon trigonatus* and *Philodryas trilineata*, Miranda et al. 1983; Di Pietro et al. 2016, respectively) probably restrict the limit of the Central domain in Buenos Aires province and confirm, in part, the observations of Ringuelet (1955, 1961) and Ringuelet and Arámburu (1957).

The Northeast presented high biogeographic similarity with the Reserva Natural Punta Lara and with the Parque Costero del Sur. The group integrated by these regions recognised the Subtropical domain in Buenos Aires province, with the austral limit on the coast of Río de la Plata (Ringuelet 1955, 1961; Ringuelet & Arámburu 1957), and it differentiated by an exclusive set of snakes (e.g. *Helicops* spp., *Erythrolamprus semiaureus*). On the other hand, the Salado River Basin, which is part of the Pampean domain, presented high values of biogeographic similarity with the Parque Rafael de Aguiar and the Reserva Natural Otamendi, which are part of the Subtropical domain. The linkage of these regions evidenced the presence of impoverished Subtropical fauna in the Pampean domain, as previously proposed by Ringuelet (1961).

In conclusion, the results obtained in this study partially contrast with the classic zoogeographic scheme of Ringuelet (1955, 1961) and Ringuelet and Arámburu (1957). The snake assemblages allow recognising a more significant division between Central and Pampean domains. In this scheme, the limit between these two regions moves to the southwest of the classical scheme; therefore the Sierras de Ventania is part of the Pampean domain. Besides, the recognition of the Subtropical domain is clear, as well as its faunistic link with the Pampean domain.

Geolocation Information

Study Area 1 (point): 33°48'S, 59°17'W; Study Area 2 (point): 33°18'S, 60°13'W; Study Area 3 (point): 34°14'S, 58°53'W; Study Area 4 (point): 34°47'S, 57°59'W; Study Area 5 (point): 36°00'S, 57°18'W; Study Area 6 (point): 35°44'S, 58°43'W; Study Area 7 (point): 36°56'S, 60°09'W; Study Area 8 (point): 37°50'S, 58°05'W; Study Area 9 (point): 38°40'S, 59°06'W; Study Area 10 (point): 38°03'S, 62°02'W; Study Area 11 (point): 37°57'S, 65°39'W.

Acknowledgements

We thank the herpetologists Diego Barrasso, Santiago Nenda and Sergio Rosset for their help during fieldwork and specimen collection, and Marcela Quetglas who read a preliminary version of the manuscript. We are grateful to the Organismo Provincial para el Desarrollo Sostenible (OPDS, Buenos Aires) for the collecting permits. We thank curators of collections

Julián Faivovich (MACN – Museo Argentino de Ciencias Naturales, Buenos Aires) and Sonia Kretzschmar (FML – Fundación Miguel Lillo, Tucumán) for loaning specimens in their care.

Funding

This work was supported by the Consejo Nacional de Investigaciones Científicas y Técnicas [CONICET, Argentina]; Secretaria de Ciencia y Técnica, Universidad Nacional de La Plata [SECYT, UNLP, project 11/N823]; and Secretaría de Ciencia y Tecnología, Universidad Nacional de Córdoba [SECYT, UNC, project 05/I460].

Disclosure statement

No potential conflict of interest was reported by the authors.

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Table 1. Confirmed snake species in the compared regions. References: Northeast (NE), Parque Rafael de Aguiar (PRA), Reserva Natural Otamendi (RNO), Reserva Natural Punta Lara (RNPL), Parque Costero del Sur (PCS), Salado River Basin (SRB), Sierras Bayas (SB), Sierras de Balcarce and Mar del Plata (SBM), Coastal Dunes (CD), Sierras de Ventania (SV) and Sierras de Lihué Calel (SLC). See Materials and methods for particular departments and source of information.

TAXON	**NE**	**PRA**	**RNO**	**RNPL**	**PCS**	**SRB**	**SB**	**SBM**	**CD**	**SV**	**SLC**
DIPSADIDAE											
Boiruna maculata (Boulenger, 1896)											X
Erythrolamprus jaegeri coralliventris (Boulenger, 1894)	X	X		X							
Erythrolamprus poecilogyrus sublineatus (Cope, 1860)	X	X	X	X	X	X	X	X	X	X	
Erythrolamprus s. sagittifer (Jan, 1863)											X
Erythrolamprus semiaureus (Cope, 1862)	X	X	X	X	X						
Helicops infrataeniatus Jan, 1865	X	X		X	X						
Helicops leopardinus (Schlegel, 1837)	X	X		X	X						
Lygophis anomalus (Günther, 1858)	X	X	X	X	X	X	X	X	X	X	
Lygophis elegantissimus (Koslowsky, 1896)										X	
Oxyrhopus rhombifer bachmanni (Weyenbergh, 1876)											X
Oxyrhopus r. rhombifer Duméril, Bibron & Duméril, 1854							X	X	X	X	
Paraphimophis rusticus (Cope, 1878)	X	X	X	X	X	X	X	X	X	X	
Phalotris bilineatus (Duméril, Bibron & Duméril, 1854)	X				X			X	X	X	X
Philodryas aestiva subcarinata (Boulenger, 1902)	X		X	X	X	X			X	X	
Philodryas agassizii (Jan, 1863)								X		X	X
Philodryas patagoniensis (Girard, 1857)	X		X	X	X	X	X	X	X	X	X
Philodryas p. psammophidea Günther, 1872											X
Philodryas trilineata (Burmeister, 1861)											X
Pseudotomodon trigonatus (Leybold, 1873)											X
Psomophis obtusus (Cope, 1863)	X										
Taeniophallus poecilopogon (Cope, 1863)					X	X					

Thamnodynastes hypoconia (Cope, 1860)	X	X	X	X	X	X			X		
Thamnodynastes strigatus (Günther, 1858)	X			X							
Tomodon ocellatus (Duméril, Bibron & Duméril, 1854)	X			X	X	X					
Xenodon dorbignyi (Duméril, Bibron & Duméril, 1854)	X				X	X	X	X	X	X	
Xenodon semicinctus (Duméril, Bibron & Duméril, 1854)									X	X	X
ELAPIDAE											
Micrurus pyrrhocryptus (Cope, 1862)											X
LEPTOTYPHLOPIDAE											
Epictia australis (Freiberg & Orejas Miranda, 1968)										X	X
Epictia munoai (Orejas Miranda, 1961)	X			X	X		X	X	X	X	
Rena unguirostris (Boulenger, 1902)											X
VIPERIDAE											
Bothrops alternatus Duméril, Bibron & Duméril, 1854	X	X	X	X	X	X	X	X	X	X	
Bothrops ammodytoides Leybold, 1873							X	X	X	X	X
Bothrops diporus Cope, 1862											X
Total species richness	**17**	**9**	**8**	**14**	**15**	**10**	**9**	**11**	**13**	**15**	**15**

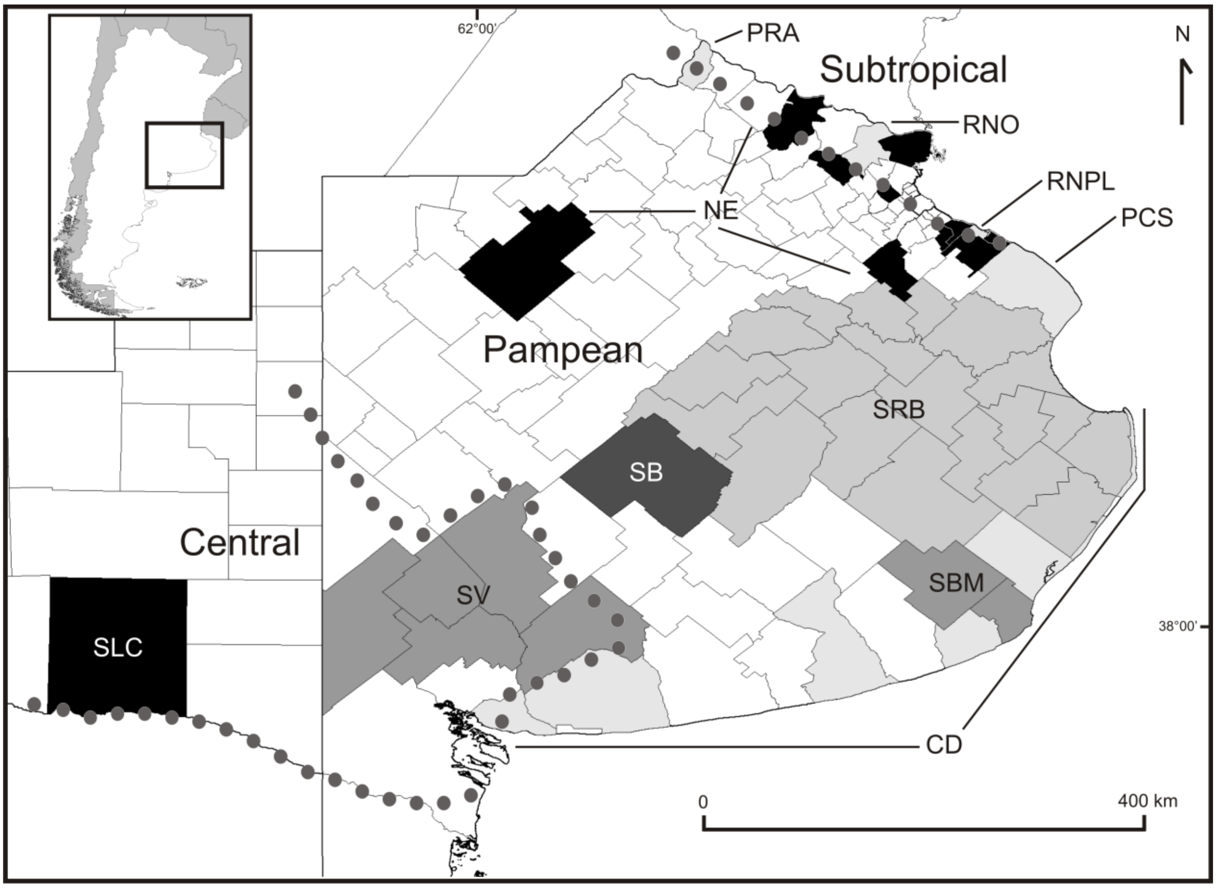
Table 2. Coefficient of biogeographic resemblance (CBR) among compared regions. Species in common to each pair (underlined), total of species (diagonal in bold) and CBR (italics). See other references in Table 1.

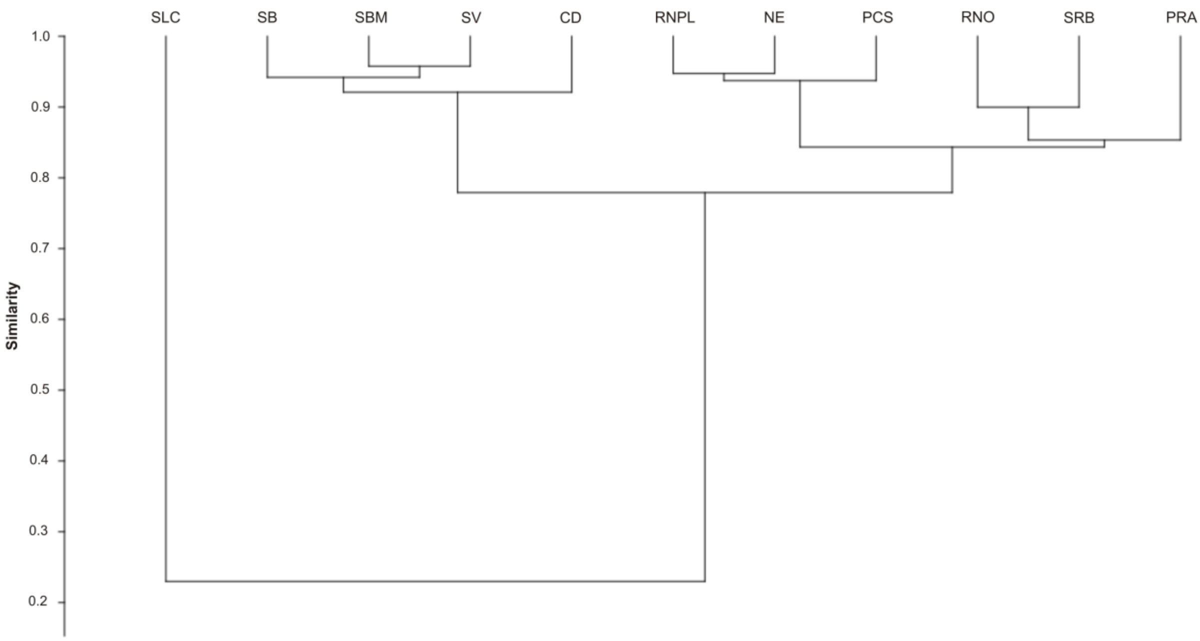
	NE	PRA	RNO	RNPL	PCS	SRB	SB	SBM	CD	SV	SLC
NE	**17**	9	8	14	14	9	7	8	10	9	2
PRA	*0.69*	**9**	6	9	8	5	4	4	5	4	0
RNO	*0.64*	*0.70*	**8**	8	8	7	5	5	7	6	1
RNPL	*0.90*	*0.78*	*0.72*	**14**	12	8	6	6	8	7	1
PCS	*0.87*	*0.66*	*0.69*	*0.82*	**15**	10	7	8	10	9	2
SRB	*0.66*	*0.52*	*0.77*	*0.66*	*0.80*	**10**	6	6	8	7	1
SB	*0.53*	*0.44*	*0.58*	*0.52*	*0.58*	*0.63*	**9**	9	9	9	2
SBM	*0.57*	*0.40*	*0.52*	*0.48*	*0.61*	*0.57*	*0.90*	**11**	10	11	4
CD	*0.66*	*0.45*	*0.66*	*0.59*	*0.71*	*0.69*	*0.81*	*0.83*	**13**	12	4
SV	*0.56*	*0.33*	*0.52*	*0.48*	*0.60*	*0.56*	*0.75*	*0.84*	*0.85*	**15**	6
SLC	*0.12*	*0*	*0.08*	*0.06*	*0.13*	*0.08*	*0.16*	*0.30*	*0.28*	*0.40*	**15**

Figure captions

Figure 1. Detail of compared regions in the context of the Ringuelet's (1961) zoogeographic domains. References: Northeast (NE), Parque Rafael de Aguiar (PRA), Reserva Natural Otamendi (RNO), Reserva Natural Punta Lara (RNPL), Parque Costero del Sur (PCS), Salado River Basin (SRB), Sierras Bayas (SB), Sierras de Balcarce and Mar del Plata (SBM), Coastal Dunes (CD), Sierras de Ventania (SV) and Sierras de Lihué Calel (SLC). Dotted lines indicate the limits, from west to east, of the Central, Pampean, and Subtropical domains, respectively.

Figure 2. Dendrogram of compared regions based on CBR, using the UPGMA algorithm and Bray-Curtis similarity index. See other references in Figure 1.

407 
62°00'
PRA
Subtropical
N
RNO
RNPL
NE
PCS
Pampean
SRB
SB
Central
SBM
SV
38°00'
SLC
CD
0
400 km

408 
SLC
SB
SBM
SV
CD
RNPL
NE
PCS
RNO
SRB
PRA
Similarity
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2